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ABSTRACT

This report is an early release of a measurement instrument used in a longitudinal project Management Implications of Team Teaching (MITT), and is taken from a larger, technical Project MITT report, "Governance and Task Interdependence in Schools: First Report of a Longitudinal Study." The instrument, "task interdependence," concerns the relationships that arise among classroom teachers by virtue of their location with respect to one another in the workflow. The report presents the theory for the concept and details operational indicators for its measurement. Some initial findings on instructional organization, based on 28 Project MITT schools, are summarized. (MLF)

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Task Interdependence Among Teachers: Measurement & Findings

W.W. Charters, Jr.

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Preface

Most reports of research come at the conclusion of a study. However, in the case of a longitudinal project, such as this one, a number of important advances deserve independent and early release. Among them are novel and potentially useful measurement operations. In Project MITT, we have developed four unique measures of variables central to our study and prominent to many other theoretical and empirical efforts. Here we report on the measurement and analysis of *Task Interdependence Among Teachers*. The other members if this short series of reports are *Control Structure in Elementary Schools*, *Sense of Teacher Work Autonomy*, and *The Norm of Teacher Autonomy/Equality*.

This report on the measurement of task interdependence among elementary teachers was prepared by W. W. Charters, Jr. He, in conjunction with John S. Packard and Richard O. Carlson, made the conceptual and practical breakthroughs that eventuated in this new and powerful measurement device. Tom Jovick performed many of the early and more tedious analyses which are the basis of much of the discussion of findings. Special thanks go to members of the faculty of the Edgewood Elementary School in Eugene who participated in pilot tests of earlier forms of the measure.

This paper has been taken from a larger, technical Project MITT report, *Governance and Task Interdependence in Schools: First Report of a Longitudinal Study*. It is published separately for those who seek easy access to the measure and related developments. To keep costs to a minimum we have elected to retain the pagination scheme of the full report. Otherwise this segment stands alone.

John S. Packard

Task Interdependence Among Teachers: Measurement and Findings

A central question of the MITT study is whether the several consequences of "team organization" reported in the percursor investigations of Pellegrin and of Meyer and Cohen can be traced to an alteration in the managerial structure of schools or to a change in instructional organization. Confusion is introduced by the fact that the same, or highly similar, words are used by educators to refer to the particular management structure and to the particular instructional organization--"teams," "teaming," "teaching teams," "team teaching," and so on. On the one hand, "team teaching" ordinarily refers to a type of instructional organization in which two or more teachers jointly carry out instructional operations for the same group of students rather than each working alone with his own class (Shaplin, 1964), and teachers operating in such a mode typically refer to themselves as a "teaching team." A school in which this instructional organization is the prevailing mode sometimes is characterized as having a "team organization." At the same time, when the managerial structure of an elementary school is altered and the teaching faculty is formed into small, subsuming units, the units are often labeled "teams" and this school, too, is said to have a "team organization."

To answer the central question, it was necessary for MITT researchers to maintain a firm distinction between changes in the school's managerial system and changes in its work system. Changes in the

school's instructional organization, according to the research plan, were to be observed by continuous monitoring. This appendix describes our work toward conceptualizing and measuring the instructional organization of elementary schools, in particular the extent of task interdependence among teachers.

Conceptualization

The MITT staff chose not to confine the measurement problem to team teaching *per se*--to the mere determination of whether or not a team mode of organization obtains among a set of classroom teachers. Our decision was based, in part, on the fact that the term is used in the ordinary parlance of school practitioners to cover widely disparate instructional patterns and impromptu arrangements, depending on the immediate context and particular advantages to the user, and on our recognition of the semantic tangles into which a precise but arbitrary definition would lead. We saw utility in a procedure that would lend itself to objective measurement and not depend on self-descriptions or the varying definitions of respondents. Moreover, we believed it would be valuable to develop a measure around a generic property of productive organizations rather than around a concept that was specific to the school (and to the elementary school, at that).

The concept of *task interdependence*, found in the literature of organization theory, seemed especially propitious for expressing a key ingredient of the idea of team teaching and, at the same time, for referencing a basic dimension of an organization's work system. As used here, task interdependence concerns the relationships that arise among

primary workers in an organization (meaning classroom teachers in our case) by virtue of their location with respect to one another in the workflow. Following the writings of Weick (1965), interdependence exists between two workers to the extent that the task performance of one worker constrains, augments, or otherwise poses contingencies for the performance of the other. The relationship can be asymetric, of course, such that one poses contingencies for the other but not *vice versa*, a condition caught up in the idea of sequential interdependence (Thompson, 1967) or simply dependence, but we will not use this terminological refinement here.[1] Task interdependence has theoretical import for the managerial functions of a cooperative enterprise. The condition of task interdependence in a goal-oriented organization sets up a need for coordination--an organizational need for mechanisms to minimize the occurrence of contingencies that would cause task performance to suffer. Forms of task interdependence, too, help shape and define the character of social relationships emerging among the organization's participants.

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[1]We have restricted our attention to task interdependencies mediated by the workflow. There are other types, and typologies, that do not implicate location in the workflow, or implicate it only in a general sense. Thompson's (1967) pooled interdependence is a case in point. We have delineated a type similar to pooled interdependence of especial relevance to the managerial functions of schools, and potentially, to the operation of managerial units in unitized schools. We call it *resource interdependence*: the circumstance in which two or more teachers draw on the same scarce resources each requires for his teaching (resources like materials, space, or the services of specialists and paraprofessionals). In principle, the particular sites of resource interdependence can be identified in the school and investigation made of procedures for coordinating or resolving conflicting demands, including the locus of responsibility for doing so. The connection of this with the school's control structure, discussed elsewhere in the report, should be apparent.

Pupilflow. The idea of workflow comes from industrial engineering, where the technical terminology and analysis procedures have had a long and distinguished developmental history (*e.g.*, Maynard, 1956, Sections 2, 6). In our present application, however, we have in mind the simple notion of the movement of pupils from one teacher to another for the purpose of classroom instruction; we refer to it as *pupilflow*. In identifying the pupilflow(s) in a school, and thereby defining instances of task interdependence, it is crucial to specify a time frame within which the flow is to be considered. If viewed within the time frame of an academic year, a school might show no teacher-to-teacher movement of pupils at all, each teacher working independently with his or her own class; but if the time frame were extended to encompass two years, the flow would link teachers of adjacent grades; and a longer extension would produce interdependence among still more teachers.

Team teaching and its alternatives (the self-contained classroom, departmentalization) describe characteristics of the pupilflow within the boundaries of an academic term or year, so a less extended time frame is the relevant one for our purposes. Since the academic year constitutes a naturally occurring activity cycle of most American elementary schools (excepting the few with semi-annual promotions), and a convenient dividing line between less and more subsuming time frames, we have used it as the frame for defining task interdependence.

In principle, a school could have no pupilflow at all, as would be true in the pure type of the self-contained classroom, or it could have as many different flows as there were pupils. In practice,

the latter is an unmanageable situation for any but the tiniest of schools, although efforts to move in some degree in that direction are envisioned by programs of highly individualized instruction. As a matter of necessity for pupils and teachers alike, schools "batch" pupils for purposes of instruction, typically by grade-level and classroom, and channel the inter-teacher flows, if such occur, in a regularized fashion. The pupilflows in a school could be quite discrete, linking certain teachers in an interdependent system and holding them apart from other teachers, or the pupilflows could entail considerable cross-overs among teachers, connecting a larger number but perhaps less intimately. Thus, a special program for mentally handicapped children might confine the pupilflow to the specialist teachers working together as a tightly-knit group in isolation from the remainder of the school, or the program could be operated by moving the pupils into and out of the regular classrooms, thereby creating interdependencies with other teachers. Apart from the educational implications, which can be argued on both sides, the choice of pupilflow, we believe, has an important influence on the school's adult social structure.

Our conceptualization suggests that it is important to distinguish two types of task interdependence arising from teacher location in the pupilflow--important because the means required for achieving coordination differ substantially in their time-costs and conditions for success, and also because they represent the two general directions which teacher collaboration typically take. One is *throughput interdependence*, the less demanding of the two (in schools), and the other we call *instructional interdependence*.

Throughput interdependence. In serial manufacture and like productive systems, a worker cannot begin a step in the processing sequence until the material to be processed has been released and delivered from the preceding step. In some circumstances, where unforeseen contingencies produce large variations in rates of processing, effects on the task performance of workers later in the sequence can assume important proportions, and one common means of reducing the effects of such time dependence is to maintain buffer inventories of the products completed in the preceding step (March and Simon, 1958).

The school cannot be construed as akin to serial manufacture nor can pupils be stockpiled for later processing as physical throughput materials can,[2] but there is a clear parallel to this form of interdependence in the pupilflow. Throughput interdependence refers to the circumstance in which one teacher cannot proceed with his or her instructional activities until the pupils he or she is to teach are released by another teacher. Thus, the lesson plan of the regular classroom teacher for a social studies unit may be impacted if the physical education teacher keeps the class, or even part of the class, on the playground an extra tem minutes to complete an activity.

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[2]It is interesting, though, to consider common school practices from the viewpoint of stockpiling. Jackson (1968) noted with surprise the amount of time in the classroom day pupils spend in waiting--waiting in lines, waiting to recite, waiting for the teacher's help, and so on. Enrichment activities and end-of-year reviews for students who finish the year's work early may be seen, too, as a means to avoid encroaching on the instructional program of next year's teacher.

The obvious coordinating mechanism for throughput interdependence is the class schedule, often accompanied by bells or other audible reminders signalling the end of periods. While the initial task of establishing the schedule may take some effort and severe disruptions may accompany frequent schedule changes (Reynolds, 1972), it is a low-cost, impersonal, and generally effective coordinating device.

Instructional interdependence. Where the preceding type of interdependence concerns only those contingencies teachers pose for one another in the timing of their work, instructional interdependence focuses on the substance of task performance--on the ways beyond timing in which the instructional plans and activities of one teacher hinder or augment the activities of another. The teaching-learning process is not like many other productive systems where processing steps are narrowly and intimately cumulative, where the success of a processing activity hinges on the successful completion of an immediately preceding activity. With enough time, of course, some sectors of the educative process can, indeed, be seen as cumulative; a class in English literature can hardly be taught to pupils who have not yet learned to read. But in the short run, such sequential dependencies are the exception, not the rule, and are likely to remain so until the technology of instruction is substantially advanced.

Nevertheless, one can envision gross ways in which the instructional activities of one teacher can affect the plans and activities of others with whom s/he work. An organizational pattern for science, for example, where one teacher is to put on a puzzling demonstration for the

assembled pupils, the educational point of which is to be brought out in follow-up discussion sections by several other instructors, would certainly fail in purpose if none of the latter knew what the demonstration had been or what its point was. Two teachers teaching American history together in the same room would obviously be disaccomodated if one planned for pupils to work on their independent writing projects and the other intended to show a film. These illustrations are gross, but they point out the general character of the contingencies and the essentiality of coordination among the implicated teachers.

The means of coordination that prevent teachers from working at cross-purposes and otherwise disaccomodating one another in situations of instructional interdependence are not obscure, but they introduce significant new conditions of success. Coordination simply involves people talking to one another, letting others know of one's ideas and intentions, and then of making mutual adjustments. Coordination is achieved by face-to-face communication, perhaps no more than a few words or a sign, and by a willingness to accede to one another in the event of differing ideas. The mechanism, however, is no longer an impersonal one like a schedule, which can be effective even if the participants do not know each other, even if they are bitter enemies. Rather, it invokes a social relationship in which meanings are exchanged, points of view explored, status relations acknowledged, and self-worth exposed, and success of the mechanism is as fragile or strong as the personal relationships on which it depends. It is a

comparatively high-cost device in terms of the time it requires for communication and the resolution of differences, the more so the more frequently teachers join together in the instructional process and thereby pose contingencies for one another. The costs are especially great when the personal relationships have yet to be established or when disparities in educational views are wide and adamantly held, but still they can diminish to a low level over time as the participants gain the experience and assurance of working together.

The two types of task interdependence we have outlined correspond to the two directions instructional organization can take when teachers in the elementary school are urged to form collaborative work systems or "teaching teams" among themselves. One direction is to divide the labor along subject-matter lines (Teacher A to handle all the science instruction for the combined pupils, Teacher B to teach math, Teacher C social studies, and so on), to set up a system of periods and classes, and to establish a schedule that appropriately routes pupils through the classes and periods. Each teacher teaches his or her subject to the classes independently of the other teachers and is linked to them solely by throughput interdependence. This direction extends to academic subjects of the elementary school the pattern commonly applied to art, music, and physical education and, obviously, emulates the conventional pattern of high school and college. The pattern is modified in many ways--in numbers of teachers implicated, number of subject-areas divided, and on and on--and, indeed, the possible permutations of teachers and subjects

seems almost without limit.[3] As intricate as the pattern may be, it operates essentially as a system of throughput interdependencies.

The other direction is toward what we might call, for want of a better term, *bona fide* team teaching. In one of the rare analytical treatments of a programmatic innovation in education, Shaplin defined team teaching as,

> a type of instructional organization, involving teaching personnel and the students assigned to them, in which two or more teachers are given responsibility, working together, for all or a significant part of the instruction of the same group of students (Shaplin, 1964, p. 15)

Elaborating on the clause, *for all or a significant part of the instruction*, Shaplin emphasized that, while projects may start in a very small way with teachers collaborating in only one class or subject area as a strategy for introducing teachers and students to the processes of team teaching, the label is not justifiably applied until joint instruction occurs in most of the curriculum areas. This precludes the kind of subject-matter division of labor described above where each teacher teaches his or her subject alone. Thus, a step in the direction of *bona fide* team teaching is a step in which not only do two (or more) teachers teach the same pupils, but they teach them in the *same subject area*.

It is defensible to argue, we believe, that contingencies in the substance of instruction--the kind that define instructional

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[3] We calculated once that there are 534 ways in which up to five teachers can be implicated in teaching five subjects, assuming that between them all subjects are taught.

interdependence for us--are far more likely to occur when two teachers teach their common pupils the same subject than when they teach them different subjects. That is, it is much more essential for each to take account of what the other is doing with the class if both are teaching science, say, than if one is teaching science and the other social studies. This is not to deny the possibility of contingencies arising between two teachers who are attempting to "correlate" their two subjects, but this is so rare a condition in elementary schools (and effects of breakdowns in coordination so imperceptible) that we feel we can ignore the contingencies without doing undue violence to the bulk of educational practice.

In sum, throughput interdependence obtains between teachers sharing pupils in the pupilflow when they teach them different subjects; carried far enough, the pattern corresponds to the conventional mode of high schools and colleges and often is referred to as departmentalization. Instructional interdependence exists when teachers not only share in the same pupilflow but teach in the same subject area; carried far enough, the pattern represents *bona fide* team teaching.

There are yet other patterns of instructional organization that escape the net of the two prominent directions of movement. Aside from the state of task *in*dependence where pupilflows are nonexistent (the pure type of self-contained classroom), a form worth noting entails a redivision and reassignment of the pupils in two or three classrooms for instruction in a particular subject. Thus, two teachers may identify the reading abilities of pupils in their respective classes, one agreeing to

teach the "low" group for a term and the other to teach the "high" group; it is, in effect, an effort to achieve homogeneous grouping. Applied to enough subgroups, the pattern approaches a purely individualized instructional program.

Degrees of task interdependence. There is considerable utility for measurement purposes in applying a metric to an organizational property like task interdependence, or to each of the component types, and we have formulated a basis (as well as an operational procedure) for doing so with respect to instructional interdependence. In measuring the *intensity* of instructional interdependence between a pair of teachers, we begin with the fundamental assumption that intensity is a direct function of the frequency of events that are likely to impose contingencies and thereby demand coordination. As we have noted, instructional interdependence ordinarily requires communication directly between the parties involved in the task performance. Thus, a more colloquial way of phrasing the assumption is that the more often teachers teach together, the more often they must talk about what they are going to do or what they have done in order to avoid working at cross-purposes.

The concept of *rate of pupil exchange* is our operational indicator of the frequency (per unit of time) of these contingency-imposing events. We assume that the rate at which pupils move back and forth between two teachers for instruction in the same subject, the more often they must take account of and adjust to one another's

instructional activities. The extreme of the rate is reached when both teachers work with the pupils simultaneously in the same room. Thus, the intensity of instructional interdependence is immediately expressed by the rate of pupil exchange between the implicated teachers.

By the definition of instructional interdependence, the pupil exchange in question occurs for a given subject, and our operational procedures, which we explain shortly, permit us to obtain information about exchanges by subject. In order to reach an intensity score for a pair of teachers, we sum the rates of exchange over all their common subject areas. We have used an unweighted, additive score, since we lack a rationale for weighting subject areas according to the severity of the contingencies likely to be imposed, and have no compelling reason to suppose that the severity of contingencies, or strength of coordination demands, is something other than cumulative as the number of subjects increases.

Intensity of instructional interdependence applies to a *pair* of teachers. The pair-wise scores intensity scores may be aggregated for all the possible pairs of teachers at a grade level, in a system of interdependence, in a managerial unit, or in the school, depending upon one's interests. We refer to such an aggregation across pairs as the *extensity* of instructional interdependence, noting of course the particular collectivity of interest.

As of this writing, the intensity metric has not been derived systematically from our data. Later in the appendix we describe the

abbreviated indexes that have been developed and used in these first data analyses.

Measurement Procedures

As our foregoing conceptualization has delineated, it is necessary to identify teachers who are connected by the pupilflow(s) in order to describe the instructional organization of the school and to measure task interdependence. The method developed by the MITT staff entailed, first, obtaining from each regular classroom teacher a record of his or her instructional contacts with a sample of the school's pupils for ten consecutive school days and, then, reassembling the information to reveal instances in which pupils were taught by two (or more) teachers and whether the pupils' instruction was in the same subject or whether it was in different subject areas.

The teacher logs. To facilitate the record-keeping process, the research staff furnished teachers with a "teacher log" fashioned after the familiar attendance booklet. Down the left side of the page is a list of pupils in the school whom the teacher *might* teach in the course of two weeks (actually running to three or four pages in a large school), and five half-pages represent five standard subject areas in which elementary-school pupils receive instruction. Ten columns on each half-page allow the teacher to make a record of whether or not s/he taught a listed pupil in the subject on each of ten consecutive school days. Along with a space for the teacher's name and for the beginning and ending dates of the record, the log form provided the

basic information from which the appropriate reassemblies could be made. A number of considerations and procedural details were involved in developing the booklets that need to be described.

Subject areas. Five subject areas were chosen for inclusion in the teacher logs:

Social studies
Science
Language arts
Reading
Math

These five areas were chosen on the grounds that they are universal in elementary schools. Excluded are several additional subjects often (but not always) taught by subject-matter specialists, *viz.*, art, music, and physical education. They were excluded because the instructional reorganization of concern in the MITT study, and the reorganization envisioned by the idea of team teaching and the IGE innovation in which the experimental schools of the study are engaged, focuses on regular classroom teachers and the academic subjects they normally teach.

Our restriction of the data collection to regular grade-level teachers and the academic subjects has an important effect of underestimating the task interdependence in schools of the study, especially that of the throughput variety. Our procedure does not record the interdependence between classroom teachers and the various subject-matter specialists who might be in the school nor does it describe pupilflows between the regular classrooms and various special programs (like bilingual programs, readiness programs, transition classrooms, or programs for the physically or mentally handicapped) when taught by teachers identified as specialists.

The procedure could readily be extended to portray interdependence in its full array in elementary schools, but full description is not germane to the specific purposes of the MITT Project.

The time sample. Teachers were asked to log their instructional contacts with pupils daily for ten consecutive school days. We conceive the two-week interval to be a time sample of all such intervals during a school term (that is, during a period of four-and-a-half months from September through December or January through May). We have no evidence at this point regarding the variability of descriptions in the universe of intervals, but we suspected that the period preceding holidays and end-of-term or year recesses would produce atypical patterns, so an effort was made to avoid such periods in collecting logs. In general, the logs were made in mid-November and late April or early May.

Two consecutive weeks of recording seemed to be an appropriate interval length for the record-keeping process, in that it adequately covers the natural weekly cycle according to which elementary schools normally operate. At the time we chose this interval we were unaware that a three-week rhythm of pupil instruction and regrouping is recommended in the IGE instructional model. Hence, our data must underestimate task interdependence in experimental schools if the model is followed.[4]

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[4]When we became aware of the three-week cycle, we realized that we would have to ask teachers to keep logs for a full month in order to cover the regrouping periods as well as the intervening

We used the *day* as the smallest time-unit for recording instructional contacts, mainly as a matter of convenience to the responding teachers but also because of the difficulty in establishing a smaller unit, like "periods" or "modules", that would be standard across 40 or so elementary schools. The consequence of our choice is that the highest rate of pupil exchange in a measure of instructional interdependence is the instance of two teachers teaching the same subject (to the same pupils) on the same day, which is only a rough approximation of their teaching simultaneously in the same room, our conception of *bona fide* team teaching.

The pupil sample. The purpose of our logging procedures is to determine the task interdependence of teachers, using information about individual pupils only to represent the general pupilflows that connect the teachers. Thus, it is appropriate to sample from the roster of pupils in the school rather than to list the entire school enrollment. Indeed, the latter procedure would have made the teacher logs a forbidding document for teachers to handle in the larger schools. We decided to limit the number of pages of pupil names to five; at 35 names to the page, the longest set of names would be 175.

Pupil rosters were obtained from participating schools shortly

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instructional arrangements. We decided not to extend the interval because of the inordinate demand it would put on the participating teachers. Moreover, while the extended interval would, perhaps, more faithfully display the IGE instructional pattern, it would not add appreciably to a measure of the intensity of instructional interdependence based, as it is, on the *rate* of pupil exchange.

after the opening of school each year. (To prepare the mid-year teacher logs, we merely asked principals, or clerks, to up-date the fall rosters.) Typically, the rosters were arranged by teachers or classrooms when they reached the MITT office, occasionally by "units" or "teams." Using a random procedure, we chose six or seven pupils from each classroom in the smaller schools or five pupils in the larger schools, the exact number determined in part by the closest multiple of 35 that would fill up a page of the teacher log. (The work of preparing and assembling log booklets for each school was rather arduous, and we strove to obtain the largest amount of information we could with the smallest number of pages within the sampling frame employed.) If pupil rosters were arranged by units, or in some other unusual way besides teachers and classrooms, we determined the number of regular teachers assigned to the unit or group and chose the five, six, or seven pupils on a per-teacher basis.

All teachers in the school receive the same list of pupils in their log booklets, clustered insofar as possible by classrooms and by grade level to expedite the effort of teachers in locating the pupils they teach. In our first data-taking operation, however, two or three different pupil lists were prepared for each school (except the very smallest), arranged by grade-level clusters. Thus, a teacher would see in the booklet only names of pupils in grades near the level at which s/he taught. Not only were such booklets difficult to prepare and to distribute to the right teachers, but the date would

systematically underrepresent pupil exchanges between teachers extending beyond two or three grade levels. For these reasons we changed to the single list procedure described.[5]

Excluded pupils and teachers. We have emphasized several times that the concern of the MITT study is with changes in the organization of the regular educational program of grade-level teachers. For this reason, class rosters received from participation schools are closely inspected and held up against the detailed staff rosters showing teacher assignments, to certify that the classrooms are in the main line of the school's grade coverage, and do not represent special programs and classes, like nursery school programs or classes for children with speech or hearing defects. Normally the determination is readily made at the time of the pupil sampling and the preparation of log booklets, but cases that escape this screening can be identified during the reassembly of the returned logs and removed from the tabulations as necessary.

In the initial round of data collection in the spring of 1974, logs were not systematically requested from teachers of seventh and eighth grades, in the eight schools including these levels. The literature on IGE generally envisions a six-grade elementary school as the target of change efforts; moreover, several of the experimental schools of

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[5]We have not yet determined the bias our procedural change introduces between the first data-taking wave and subsequent waves, but a reasonably precise estimate eventually can be made. In any event, the great bulk of the instances of task interdependence we observed in the Time 1 records are within grade levels rather than between levels, even where the booklets list pupils from three or more levels.

the study had explicitly stated expectations to exclude the upper two grades in their implementation plans. We came to regret the exclusion, since subsequently all but one school did, in fact, include them in unit organization. From the second wave of data-taking on, we have systematically collected teacher logs from these levels.

Information reassembly. Once the teacher logs have been completed and returned, they can be reassembled to reveal pupilflows, if any, connecting various sets of teachers. The data for a given school lie in a four-dimensional space: m pupils by n teachers by five subjects by ten days. Hence, there are numerous alternatives for assembling and aggregating the information, and the problem boils down to selecting the ways relevant to one's immediate purpose. Shortly we will illustrate a few ways of describing patterns of instructional organization.

In working toward measures of task interdependence, we have found it useful to construct a teacher-by-teacher matrix for each school, entering for every pair an indication of whether or not they teach *any* of the same pupils and, if so, whether or not they teach them in the same subject, ignoring for the moment the frequency of exchange (the fourth dimension). Then instances of connection in the pupilflow are singled out for measuring throughput and instructional interdependence. Pursuing this approach, we found in the initial data a number of instances of interdependence that hinged on the common teaching of just one pupil, often just once in the ten-day period.

Sometimes these instances seemed attributable to a teacher's error in entering information in the log booklet, and sometimes they appeared to represent some unique circumstance associated with the particular pupil. Inasmuch as our interest lay in general patterns of pupilflow, we established the decision rule that at least two pupils must be taught in common in order to qualify as an instance of task interdependence.

Even ignoring the fourth dimension of *days*, the three-dimensional property space still gives rise to innumerable, occasionally complex, patterns of instructional organization, especially as the pairwise data are extended to encompass all the teachers implicated in what we have come to call *systems* of interdependence. Before describing the indexes of task interdependence used in the present monograph, we will report on some of the patterns uncovered in the Time 1 data and other findings of interest.

Some Initial Findings on Instructional Organization

Here we describe some of the observations regarding systems of interdependence that have emerged from our examination of the teacher logs obtained in the spring 1974 round of data collection. The observations are based on the 29 MITT schools classified as experimental or control by criteria reported elsewhere, less one experimental school from which teacher logs were not obtained. Overall, logs were completed by 380 of the 424 classroom teachers from whom they were requested, a return rate of 90 percent. All of the following observations disregard the frequency data--the rates of pupil exchange--except to determine the

presence or absence of a connection between two teachers; a connection is counted if two teachers teach the same pupil any time during the ten-day period.

Illustrative patterns. The figures accompanying this section are schematic representations of patterns of instructional organization found in one sector or another of the MITT Project schools, which presumably were "conventional" schools at the time the data were collected. The figures show the instructional contact of two- and three-teacher systems with eight (or 12) sampled pupils in each of the five subject areas. The x's represent the presence of an instructional contact at least once during the ten days of logging.

The diagram at the top of Figure 1 represents the self-contained-classroom mode--each teacher teaching his or her own pupils in all the subject areas. It is said to be the standard organization of elementary schools areas. If the diagram were visualized as extending to the right, covering all classroom teachers in the school, and downward to indicate all pupils, it would depict what is said to be the standard organization of elementary schools in the country. Proponents of various innovative plans almost invariably couch the advantages of their proposals against the shortcomings imputed to the standard organization. Our data suggest, however, that proponents who make the contrast today may be setting up a straw man: only one of the schools investigated by MITT researchers fully corresponded to the so-called standard. The percentages of classroom teachers in a

Figure 1. Two-teacher patterns of instructional organization.

(a)

Pupil	Teacher A					Teacher B				
	SS	Sc	Ma	Rd	LA	SS	Sc	Ma	Rd	LA
1	x	x	x	x	x					
2	x	x	x	x	x					
3	x	x	x	x	x					
4	x	x	x	x	x					
5						x	x	x	x	x
6						x	x	x	x	x
7						x	x	x	x	x
8						x	x	x	x	x

(b)

Pupil	Teacher A					Teacher B				
	SS	Sc	Ma	Rd	LA	SS	Sc	Ma	Rd	LA
1		x	x	x	x	x				
2		x	x	x	x	x				
3		x	x	x	x	x				
4		x	x	x	x	x				
5		x				x		x	x	x
6		x				x		x	x	x
7		x				x		x	x	x
8		x				x		x	x	x

(c)

Pupil	Teacher A					Teacher B				
	SS	Sc	Ma	Rd	LA	SS	Sc	Ma	Rd	LA
1	x	x	x	x	x					
2	x	x	x		x				x	
3	x	x	x	x	x					
4	x	x	x		x				x	
5				x		x	x	x		x
6						x	x	x	x	x
7				x		x	x	x		x
8						x	x	x	x	x

Key:

SS - Social studies
Sc - Science
Ma - Math
Rd - Reading
LA - Language arts

school who individually were in the self-contained mode ranged from a high of 88 percent (apart from 100 percent in the one school) down to one school at 6 percent and another with no teachers at all in the self-contained mode; 50 percent was the median of the 28 experimental and control schools. The MITT sample, of course, cannot be construed as a truly random, or representative, sample of the nation's elementary schools, but the rarity of the fully self-contained-classroom pattern in our data is sufficient at least to raise a question about the propriety of referring to it as the standard.

The next diagram (b) in Figure 1 shows a pattern in which two teachers exchange teaching assignments, one teacher teaching all of the pupils social studies, including his or her own, and the other teaching all of them science. There is a division of labor by subject-matter (each teacher "teaching to his or her strength") and they are linked in a system of throughput interdependence by virtue of the exchange. In patterns of this and some other varieties it is fairly easy to determine whose pupils are whose by inspecting the predominance of the teaching contacts, but in certain of the more complex patterns we have identified in the data, pupils cannot be regarded as "belonging" to any one teacher or classroom. (There may be "homeroom" or "home teacher" assignments in such cases, but our data-taking procedure does not detect them.)

Another instance of throughput interdependence between two teachers is depicted in (c), but one without a subject-matter division

of labor. Both teach reading, but they have regrouped their pupils according to some consideration or criterion, perhaps on grounds of a test of reading ability; each teaches one of the sub-groups. Patterns like this can become highly intricate when the regroupings are extended to more subject areas, even when only two teachers are implicated in the system.

Figure 2 depicts three-teacher systems of throughput interdependence, the first one essentially an extension of the two-teacher pattern of (b) in the preceding figure. Here the subject-matter division of labor involves social studies, science, and math, with each teacher teaching "his or her own" pupils in reading and language arts. If the principle of the extension were carried to a five-teacher system, with the addition of specialists in reading and language arts, the instructional organization would represent what some would call departmentalization. We found only one fully departmentalized pattern in the MITT Project schools, and that in one sector of a school that had been unitized for several years (and hence not among the experimental and control schools).

The second pattern in Figure 2 represents a rather more common organizational mode, where only one teacher of the set of three is truly a specialist (shown here as specializing in social studies). It illustrates the interesting case of a system in which two teachers (A and B) are not linked *directly* in throughput interdependence, only indirectly by virtue of their separate linkages with Teacher C.

Figure 2. Three-teacher systems of throughput interdependence.

(a)

Pupil	Teacher A					Teacher B					Teacher C				
	SS	Sc	Ma	Rd	LA	SS	Sc	Ma	Rd	LA	SS	Sc	Ma	Rd	LA
1	x			x	x	x					x				
2	x			x	x	x					x				
3	x			x	x	x					x				
4	x			x	x	x					x				
5	x					x		x	x		x				
6	x					x		x	x		x				
7	x					x		x	x		x				
8	x					x		x	x		x		x	x	
9	x					x					x		x	x	
10	x					x					x		x	x	
11	x					x					x		x	x	
12	x														

(b)

Pupil	Teacher A					Teacher B					Teacher C				
	SS	Sc	Ma	Rd	LA	SS	Sc	Ma	Rd	LA	SS	Sc	Ma	Rd	LA
1	x		x	x	x						x				
2	x		x	x	x						x				
3	x		x	x	x						x				
4	x		x	x	x						x				
5	x		x	x	x						x				
6	x		x	x	x						x				
7						x		x	x		x				
8						x		x	x		x				
9						x		x	x		x				
10						x		x	x		x				
11						x		x	x		x				
12						x		x	x		x				

We show Figure 3 primarily to illustrate an instance of instructional interdependence (Teachers A and B teaching the same pupils in reading) rather than just throughput interdependence of the preceding figures, but also to indicate that mixtures of throughput and instructional interdependence sometimes occur in the same system. While it schematizes a pattern actually observed in the data, it should be apparent that details of the mode and mixture can vary in almost limitless ways, defying easy characterization.

Specific findings. The following observations of the incidence of task interdependence in the 28 experimental and control schools are based on data like those in the foregoing diagrams, assembled differently, though, for ease of analysis. Here we invoke the decision rule that two teachers must teach at least two common pupils in order for the pair to be interdependent. This is still a weak definition, as it was in the preceding section, since a teacher could instruct another teacher's (two) pupils just once in the two-week interval, yet qualify the pair as interdependent.

1. Instructional interdependence is a comparatively rare event. Counting pair-wise across schools, there were 38 instances found among the 380 reporting teachers and over three times as many instances of throughput interdependence. The majority of the teacher-pairs in instructional interdependence share pupils in just one subject, although two

Figure 3. Mixture of throughput and instructional interdependence in a three-teacher system.

Pupil	Teacher A					Teacher B					Teacher C				
	SS	Sc	Ma	Rd	LA	SS	Sc	Ma	Rd	LA	SS	Sc	Ma	Rd	LA
1	x	x	x	x	x				x						
2	x	x	x	x	x				x						
3	x	x	x	x	x				x						
4	x	x	x	x	x				x						
5						x		x	x	x		x			
6						x		x	x	x		x			
7						x		x	x	x		x			
8						x		x	x	x		x			
9						x						x	x	x	x
10						x						x	x	x	x
11						x						x	x	x	x
12						x						x	x	x	x

teacher-pairs cover all five subjects together, as detailed by the following tabulation:

Number of subjects	Number of teacher-pairs
1	24
2	5
3	4
4	3
5	2

Thus, if team teaching refers to joint instruction in "all or a significant part" of the curriculum areas, it was a rare event indeed in the MITT schools at Time 1. No one subject was favored for joint instruction, incidentally, although it was somewhat greater in science and social studies than in math and reading. The small number of instances do not allow much stock to be put in this observation though.

2. Most instances of interdependence, throughput or instructional, occurred between teachers at the same grade level (65 percent) or at adjacent grade levels (25 percent). Tabulations are shown in Table 1. Because of procedures used in the first round of data-taking mentioned earlier, these figures may underestimate modestly the grade-level spread of task interdependence. In larger schools, teachers were asked to log their contacts only with a grade-level cluster of pupils, *e.g.*, primary level or intermediate level, thus constraining the possible spread, especially for teachers at the boundaries.

The tallies also show that instances of interdependence progressively increased from kindergarten and the first grade to a peak in the fifth and sixth grades. (Data were not systematically taken from seventh- and eighth-grade teachers.) Interdependencies within and between the

TABLE 1. Grade Levels of Task Interdependent Teacher-Pairs, MITT Experimental and Control Schools, Spring 1974

	Grade Level*												
Grade Level*	K	1	1-2	2	3	4	4-5	5	5-6	6	7	8	Sum
K	6	1	-	-	1	-	-	-	-	-	-	-	8
1		3	-	1	-	-	-	-	-	-	-	-	4
1-2			-	2	2	-	-	-	-	-	-	-	4
2				17	3	-	-	-	-	-	-	-	20
3					19	-	-	1	1	-	-	-	21
4						22	-	7	-	1	-	-	30
4-5							-	1	-	1	-	-	2
5								15	2	22	1	1	41
5-6									-	3	-	-	3
6										25	1	1	27
7											-	1	1
8												-	-
Sum	6	4	-	20	25	22	-	24	3	52	2	3	161

*Combinations like 1-2 represent split classrooms.

fifth and sixth grades accounted for close to half (42 percent) of the total.

3. Task interdependencies occur predominantly as two-teacher systems. While indirect linkages between teachers occasionally make it difficult to distinguish and count "systems" of four or more teachers, we found over half of the 68 systems to involve only two teachers and another one-third to be three-teacher systems. (The second diagram (b) of Figure 2 illustrated an indirect linkage.) In one school, however, there was an intricate seven-teacher system among fifth- and sixth-grade teachers, and in another a six-teacher system involving teachers of the first, second, and third grades.

System size	Number of systems
2	37
3	23
4	6
5	1
6	-
7	1

Only in a few schools did the systems appear to follow a school-wide plan. The smaller systems tended to arise more or less indiscriminately across the school, a pair of teachers here and a trio there, without obvious patterning. They seemed to be spontaneously emergent phenomena, depending on the happenstance of the teachers who were in neighboring classrooms. The larger systems usually would be present in one sector of a school (most often in the intermediate grades) but not in another. Furthermore, where a larger system occurred, say among four teachers of the fifth and sixth grades, typically there would be several

teachers of the same grades who remained outside the system, suggesting an element of voluntarism in the organizational arrangement. In short, one would be hard pressed in most cases to characterize a *school* as having one kind of instructional organization as opposed to another. It will be interesting to see if this changes in the experimental schools of the MITT study by virtue of their commitment to an instructional innovation.

4. Although a subject-matter division of labor was common in the throughput-interdependent systems, teacher *specialization* by subject was rarely observed in the schools. The concept of specialization requires us to turn attention from the distribution of activities across a set of teachers to the individual teacher and the distribution of his or her activities, since specialization can be said to occur when the teacher teaches in one and only one subject area. (Division of labor does not necessarily imply specialization, but specialization cannot occur without a division of labor.) By another reassembly of the teacher log data, we arrived at the following figures showing the number of teachers who taught one to all five of the subjects.

Number of subjects taught	Number of teachers
5	239
4	56
3	41
2	31
1	13

Just three percent of the 380 teachers specialized in a single subject, while the large majority was in the image of the "omnicompetent" teacher, covering all subjects of the curriculum.

The Indexes of Task Interdependence

Two indexes of task interdependence were developed for purposes of the present report, one for the extent of throughput interdependence in a school, the other for the extent of instructional interdependence. They entailed a simple count of the number of teacher pairs in task interdependence, noted by p_t and p_i respectively. As in the preceding section, an instance of throughput interdependence was counted when two teachers taught at least two pupils in common, but in different subjects, and an instance of instructional interdependence when the teacher-pair taught at least two pupils in common in the same subject area or areas. The number of days on which the common teaching occurred, or the number of pupil exchanges, was disregarded for the present measure: it could occur at any time during ten consecutive school days and need occur no more often than once. Given this base, the indexes reflect the extensity of task interdependence in a school.

To be useful for comparisons among schools, however, it is necessary to take account of differences in school size, or at least in numbers of reporting teachers. It is obvious that more instances could be expected in larger schools; we found modest relationships between the n of reporting teachers and instances of interdependence, a correlation of .48 for p_t and .24 for p_i, based on all 39 schools of the MITT study for which data were available.

Less obvious though is what an appropriate correction factor for size would be. Our first thought was to use the total possible pairs of teachers as a base value, dividing p_t or p_i by $n(n-1)/2$, and in fact

we computed such scores. The problem with this is that the denominator of the ratio increases as a power of school size and the ratio value for larger schools become inordinately small. The total possible pairs in a 10-teacher school, for example, is 45, in a 20-teacher school, 190, and in a 30-teacher school, 435. Larger schools suffer from using such divisors. Correlations of interdependence scores based on them and the n of reporting teachers were negative and distinctly curvilinear. From a conceptual standpoint, the total possible pairs in a school is an unrealistic base value for an index. It assumes that all of the teachers in a school would conceivably be implicated in a single system of task interdependence--that all teachers would teach all pupils.

More realistic would be a denominator that recognized the formation of systems around subsets of teachers and pupils. In reaching it we reasoned as follows. Given the practical realities of organizing and operating instructional teams and given our measuring procedures that set the upper limit of subject specialization at five, it is unlikely that more than *five* teachers would be implicated in a fully interdependent system. Five teachers represent 10 pairs. Thus, for every five teachers in a school 10 pairs could be formed, or $10(n/5)$. More simply, the denominator value is $2n$, where n is the number of teachers furnishing logs.[6]

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[6]Our computational procedure implies the use of decimals in determining system size and numbers of possible pairs, a patently absurd approach where people are involved. We conceived other procedures that used whole numbers, but they produced index values negligibly different from this computationally simple approach.

The indexes of throughput interdependence (TPI) and instructional interdependence (INI) are:

$$TPI = p_t/2n$$

$$INI = p_i/2n$$

The six- and seven-teacher systems we observed in the Time 1 data obviously are beyond the assumed maximums of system size, but they do not pose problems for the ratio values. The presence of large systems, when well connected, only means that the index values may exceed 1.0.

The indexes do not remove the effects of differences in numbers of reporting teachers altogether, at least not the TPI index. The correlation of TPI and n (over all 39 schools) was .35 and essentially linear. For INI the correlation was -.05. Our interest, of course, was not to make an exact adjustment but to avoid an overcorrection; the correlation of throughput interdependence with n, an approximate indicator of school size, may be a legitimate relationship.

Task interdependence in unitized schools. TPI and INI indexes were calculated for the seven MITT schools which were found already to have unitized managerial structures in the spring of 1974 and, hence, could not be classified as experimentals or controls in the study design. A comparison of the indexes with TPI's and INI's for the 13 control schools is made below. We hesitate to call the comparison a test of the construct validity of the indexes, because it would require us to assume a strong relationship between the school's managerial structure and its instructional organization--a relationship that is questioned by the MITT study. Nonetheless, the computations show substantially greater task

interdependence in the unitized schools than in the control schools at Time 1.

	TPI	INI
Unitized (N = 7)	.621	.201
Control (N = 13)	.139	.047
Difference	.482	.154

The differences are significant at or beyond the .01 level by a two-tailed t test. Thus, the indexes clearly differentiate between the sets of schools with contrasting managerial forms.

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